

*Reforms with temperature***(12) UK Patent Application (19) GB (11) 2 173 636 A**

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US 4287451

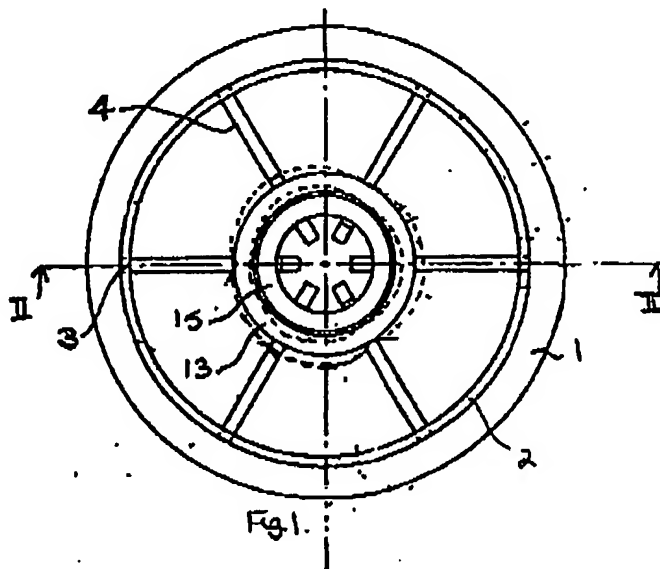
(58) Field of search

H1D

Selected US specifications from IPC sub-class H01J

(54) Magnatrons

(57) The invention concerns a resonant cavity magnetron employing a strapped vane anode (4, 9, 11, 13, 15) structure. In order to compensate for thermal variations at least one of the straps (13) is made from a material or materials having a different temperature coefficient of linear expansion to the vanes (4) such that the strap (13) will deform with temperature variation in a predictable manner to modify the resonant frequency of the magnetron. At least two straps (13, 15) may be provided connected to different alternate vanes (4) with the outer strap (13) having the greater coefficient of thermal expansion so that it deforms outwardly as the temperature rises to reduce the various strap and vane capacitances so as to compensate for the frequency variation that would otherwise occur. The higher coefficient strap is of copper, the other straps of molybdenum and the vanes of copper-clad molybdenum.



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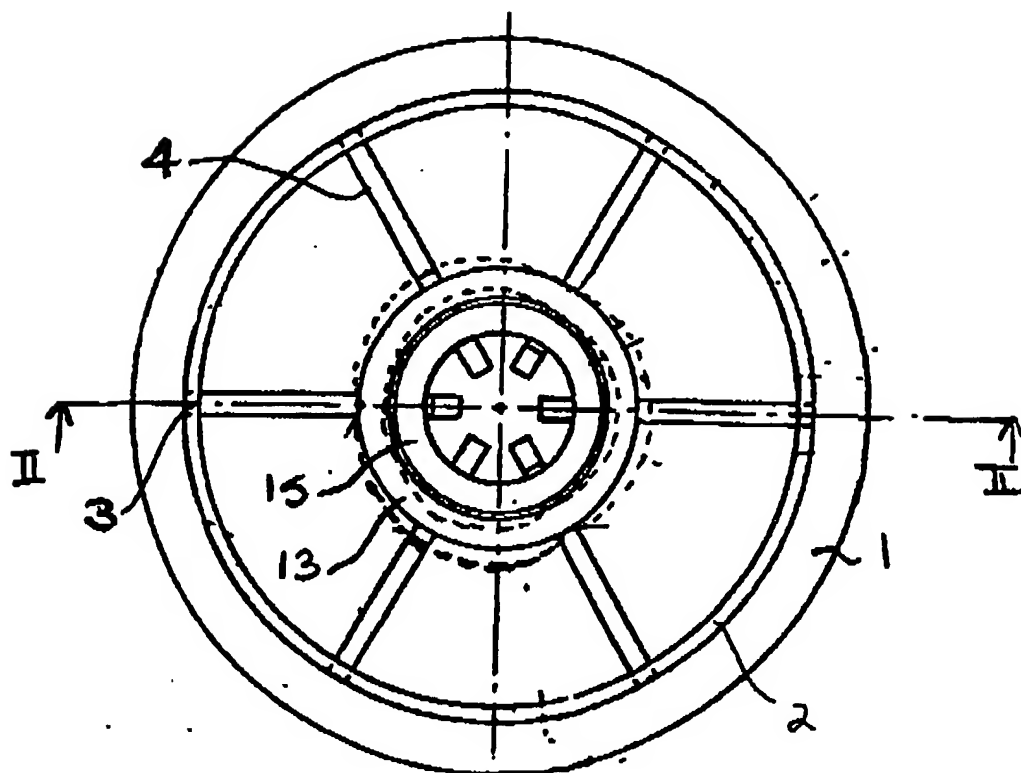


Fig. 1.

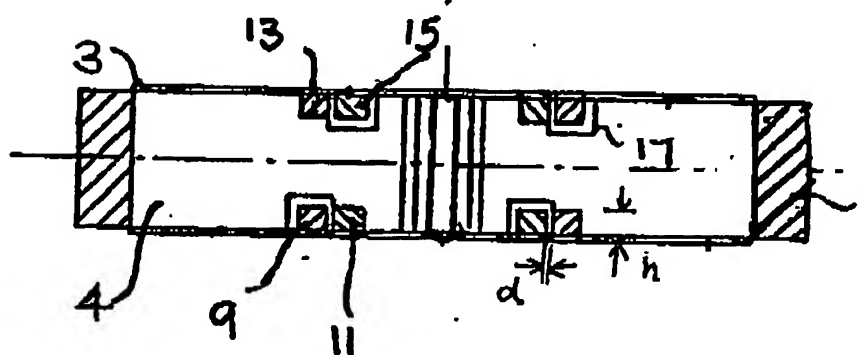


Fig. 2

## SPECIFICATION

## Magnetrons

5 This invention relates to magnetrons. In particular the invention relates to resonant cavity magnetrons employing a strapped vane anode structure.

A magnetron of this kind is disclosed in U.S.

Patent Specification No. 4,287,451. This magnetron is shown as having iron or copper strap rings which are used to strap copper vanes. The combinations of materials in the vanes and straps of this specification have been chosen to prevent vane cracking in the event of the expansion of the vanes and strap rings with temperature.

Such magnetrons comprise a cylindrical anode having a plurality of inwardly extending radial vanes which together form multi-resonating cavities. A cathode extends along the axis of the anode forming an interaction space between free edges of the vanes and the cathode. When in use an electron field is generated between the anode and the cathode and a magnetic field along the axis of the anode. Microwave energy is induced in the cavities between the anode vanes.

The temperature coefficient of frequency of such a magnetron is approximately equal to the temperature coefficient of linear expansion of the anode materials of the magnetron if endspace effects are discounted. This can cause problems whenever magnetrons of this type are to be used in conditions where the ambient temperature can fluctuate. Some reduction in the temperature coefficient of frequency may therefore be achieved by manufacturing the anode from a material having a low coefficient of linear expansion, for example molybdenum. In order to maintain a high figure of merit,  $Q_c$ , for the magnetron, the microwave conducting surfaces of the anode have to be copper clad, however.

It is an object of the present invention to provide a resonant cavity magnetron employing a strapped vane structure anode including an alternative means of controlling the temperature coefficient of frequency.

According to the present invention a resonant cavity magnetron employing a strapped vane anode structure is characterised in that at least one of the straps is of a material having a different temperature coefficient of linear expansion to the vanes which it straps, such that the strap will deform with temperature variation in a predictable manner thereby to modify the resonant frequency of the magnetron.

The invention thus resides in the appreciation by the inventor that by causing at least one of the straps to deform as a result of change in temperature, thus altering the strap to vane and the inter-strap capacitance, the resulting change in resonant frequency can be made to vary considerably from the change which might otherwise result from thermal expansion of the vane structure and/or the other parts of the anode defining the resonant cavities.

One particular resonant cavity magnetron, in accordance with the invention, will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a plan view of the anode structure of the magnetron; and

Figure 2 is a sectional view on the line II-II of Figure 1.

70 Referring to the Figures, the magnetron employs an anode structure comprising a tubular molybdenum outer wall 1, containing a copper tube 2 in which are formed six slots 3 from which extend inwardly six equally spaced, radial vanes 4 formed of copper-clad molybdenum. The structure thus comprises a re-entrant periodic structure of six coupled resonant cavities defined by the vanes 4 and the tube 2. The magnetron also includes a magnet (not shown) for providing the magnetic field required during operation of the magnetron, a cathode (also not shown) located in the space between the inner ends of the vanes 4, and a microwave output waveguide (also not shown).

The vanes 4 are provided with two pairs 9, 11 and 13, 15, of co-axial circular straps, one pair 9, 11 of which are located at the lower end of the vanes 4, the other pair 13, 15 being located at the upper end of the vanes. The straps 11, 13 are connected by brazing to one set of alternate vanes 4, whilst the straps 9, 15 are connected by brazing to the other pair of alternate vanes: slots 17 are provided in the vanes 4 where a strap 9, 11, 13 or 15 is required to pass without making electrical connection. The two lower straps 9, 11 and the innermost upper strap 15 are all formed of molybdenum, whilst the remaining strap 13 is formed of copper.

In operation of the magnetron, any increase in temperature will cause the copper strap 13 to deform outwards between its brazed connections to the vanes 4 away from its paired inner strap 15, towards the dotted configuration shown in Figure 1. By appropriate design of the anode structure, the consequent reduction in interstrap capacitance and strap to vane capacitance can be arranged to nearly exactly compensate for the frequency deviation which would otherwise occur as a result of the thermal expansion of the molybdenum vanes 4 and tube 2.

It will be appreciated that whilst in the resonant cavity magnetron described herebefore by way of example, only one strap, an outer strap, is of a different material to the vane which it straps, the invention is equally applicable to magnetrons in which more than one strap is of a different material or materials, or which employ different total numbers of straps.

With regard to fabricating the anode structure so that the inter-strap capacitance and the strap-to-vane capacitance vary in the requisite manner the following procedure should be carried out. Considering a six-vane magnetron of the kind shown in the drawings the resonators are designed to give the correct  $\pi$ -mode frequency and  $\pi$  to  $\pi-1$  mode separation by a combination of cavity lengths and theoretical value of capacitance by strapping. The vane structure being of low thermal expansion the deformation of a single strap of different metal and hence the expansion coefficient is determined theoretically at a known radius. This deformation is then employed to determine the necessary strap-strap separation to

give the correct capacitance variations to stabilise frequency against normal temperature coefficients. This separation is shown at d in Figure 2. Having thereby determined strap radius and separation, the strap height h, again shown in Figure 2, is then calculated to provide the correct total capacitance value.

#### CLAIMS

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1. A resonant cavity magnetron employing a strapped vane anode structure characterised in that at least one of the straps is of a material having a different temperature coefficient of linear expansion to the vanes which it straps, such that the strap will deform with temperature variation in a predictable manner thereby to modify the resonant frequency of the magnetron.
2. A magnetron as claimed in Claim 1, and characterised in that there are at least two coaxial straps, the straps being connected to different alternate vanes of the magnetron and passing freely the vanes to which they are not connected whereby an increase in temperature will cause the strap with the greater coefficient of thermal expansion to deform outwardly between its connections to the vanes to reduce the inter-strap and the strap-to-vane capacitance in such a manner as to compensate for the frequency variation which would otherwise have been caused by the temperature rise.
3. A magnetron as claimed in Claim 2, and characterised in that there are four coaxial straps arranged in two pairs, one pair being located at the upper ends and the other at the lower ends of the vanes, one strap of each pair being connected to one set of alternate vanes, and the other straps being connected to the remaining vanes.
4. A magnetron as claimed in Claim 3, and characterised in that one strap of the two pairs has a higher coefficient of thermal expansion than the three other straps.
5. A magnetron as claimed in Claim 4, and characterised in that the strap with the higher coefficient is the outer strap of its pair.
6. A magnetron as claimed in Claim 5, and characterised in that the higher coefficient strap is of copper and the other strap or straps of molybdenum.
7. A magnetron as claimed in any one of Claims 2 to 6, and characterised in that the connections between the straps and the vanes are brazed connections.
8. A magnetron as claimed in any one of the preceding claims and characterised in that the vanes are copper-clad molybdenum.